

# WFIRST Coronagraph Instrument Status

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### **CGI Project Status**



- Significant progress has been made in advancing coronagraph technology
  - Demonstrated simultaneous EFC and LOWF/S operation
  - Demonstrated SPC wavefront control using PISCES IFS with 18% bandwidth
- Initiated DM study to address DM stability
- Design maturation at Phase A level
- On-going work in technology development, CGI/observatory interface understanding, and Phase A design maturation



### **CGI Tech Testbeds Milestone CY'17**



- Key milestones for CY 17 concentrate on flight like configurations and operations:
- Currently the progress is on track

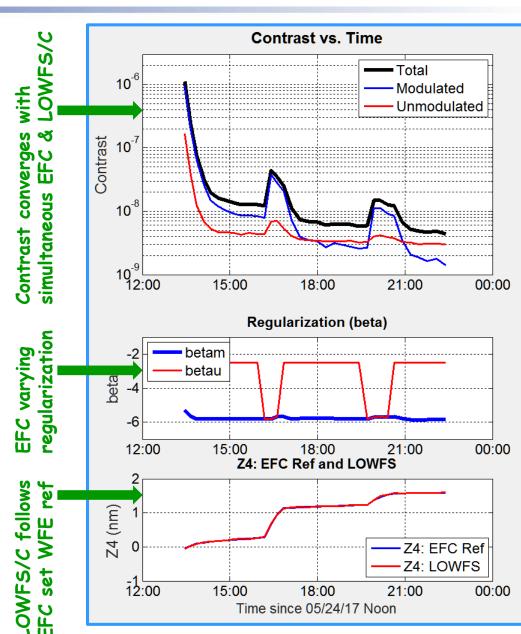
Milestones	Milestone Date	Status	Comments
PISCES commissioning done. Calibration and data pipeline in place	12/31/2016	Done	In HCIT2
Close out Milestone 9.	1/31/2017	Done	Review slides cleared
HLC wavefront control with <=3 bandpass filters (# engineering filters for flight).	3/31/2017	Done	In HCIT1, 3 bandpass done and has reached ~4e-9
Demonstrate simultaneous EFC and LOWFS/C operation.	5/31/2017	Done	In HCIT1, HLC EFC converges, LOWFS/C follows EFC reference
SPC wavefront control using PISCES IFS. 18% band high contrast.	5/31/2017	Done	In HCIT2, 18% band contrast 1.09e-8
Demonstrate SPC disc science mask performance with the imager, 6.5-20 I/D.	9/30/2017	In progress	In HCIT2, MDL mask fab started
Low light (low SNR) OMC tests	12/31/2017		In HCIT1, current testbed drift investigation will be important for this task



## OMC Testbed: Simultaneous EFC & LOWFS/C

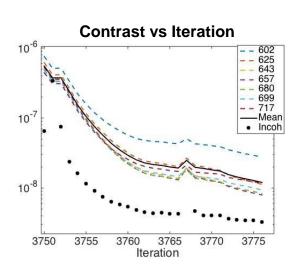


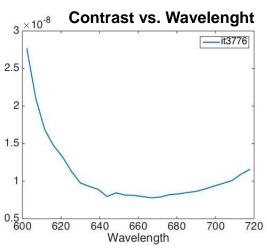
- Contrast converges with simultaneous EFC & LOWFS controls
  - Coordinated controls between EFC and LOWFS/C loops, especially joint DM operations
  - LOWFS/C follows EFC set WFE target
  - LOWFS/C is helping EFC by correcting/reducing any low order WFE not specifically set by EFC
- Contrast convergence achieved with MS9 like disturbances using OMC Testbed
  - LoS drift = 8 mas
  - LoS jitter = 1 CBE at RWA = 600 rpm
  - Focus (Z4) drift = 1 nm sinusoidal with 60 minutes period

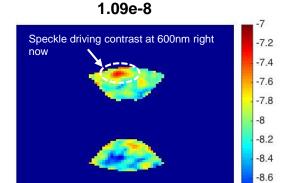




- SPC PISCES IFS 18% nulling is working well: current best contrast 1.09 × 10-8 in an 18% band with IFS
  - IFS data extraction creates 26 slices; we select 7 slices spread across the 18% band to do EFC control
  - New calibrations and operational updates (selecting slices instead of binning spectrally, jumping straight to full-band input) seems to have gotten us past previous floor
- GSFC PISCES team implemented second pipeline extraction scheme using the 2D fits in place of 1D fits
   Mean Broad Band Contrast:







-8.8



### **DM Actuator Drift**



#### Observed DM actuator drift on testbeds (OMC, Vacuum Surface Gauge)

#### Two populations

- Fast drifters ~6% "outlier"
- Slow drifters ~94% others

#### Investigation on-going to determine root cause

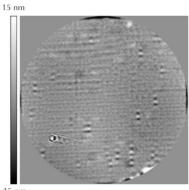
Led by Feng Zhoa

#### Potential impacts:

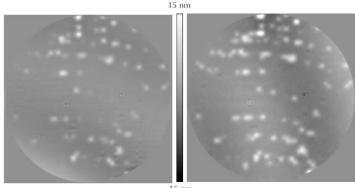
- limit integration time for science data collects
- longer dark hole convergence;

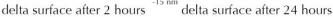
#### Possible mitigations

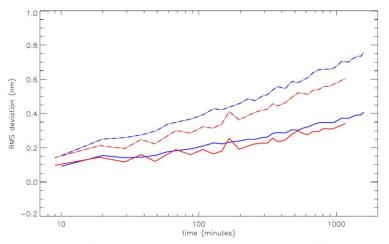
- Address root cause (probably different for each population)
- Con-Ops to include chopping and reestablishment of dark hole
- DM voltage change limits/rules such as settling time as a function of voltage change
- Use LOWFS to measure (partially) DM drifts



DM surface at start (1.8 nm rms =  $\lambda$ /350 rms)







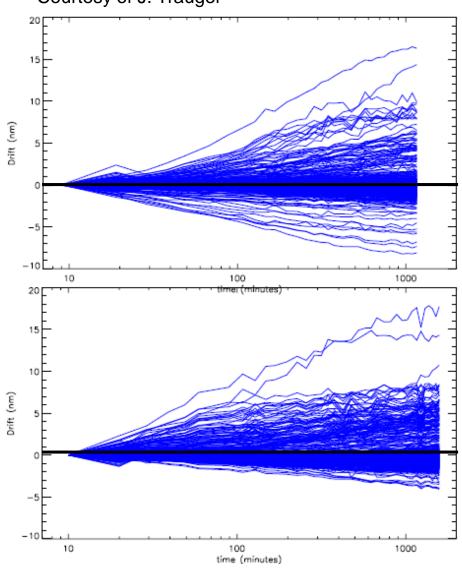
- Evolution of RMS actuator deviations from flat over a period of ~20 hours.
- Blue: no preset voltage, Red: 100 volt precondition voltage, both prior to 30-volt-flat setting.
- Dashed curves = RMS including all actuators.
- Solid curves: RMS after rejecting "3-sigma outlier" actuators.
- Outliers represent 6.7% and 5.5% of the non-conditioned and 100-volt-conditioned actuator populations, respectively.



### DM 48x48.4 Actuator Drift



#### Courtesy of J. Trauger



- Plot of peak deviations from fitted influence profiles at locations of each actuator
- Drift of 1900 actuators over ~20 hhour period (excludes edges and corners)
- Upper plot, applied voltage sequence:
  - 0 V
  - 100 V for 1 min
  - 30 V for 20 hrs
- Lower plot, applied voltage sequence:
  - 0 V
  - 30 V for 20 hrs



# **Design Maturation**



### All CGI design changes fall under normal refinement

#### 1) Optics

- 1) Polarizing optic for imaging channel
  - Wollaston prism removed one less mechanical mount
  - Three polarizers added to an existing (pre-freeze) wheel mechanism

#### 2) Thermal

1) Radiator sizes & heater zones reduced following updated thermal analysis

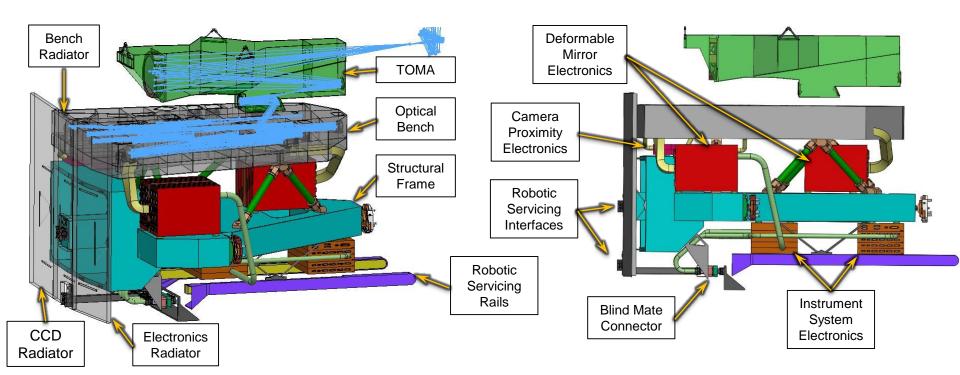
### 3) IFS

- 1) CaF imaging lens removed from the IFS camera housing to reduce Cerenkov radiation may require minor changes to optical bench internal structure
- 2) Lenslet format to change due to revised lenslet PSF sampling requirement
  - WAS: 3  $\lambda$ /D per lenslet
  - IS: 2  $\lambda$ /D per lenslet
- 3) Dispersion element to change due to revised spectral resolution requirement
  - WAS: R = 70
  - IS: R = 50



# **CGI: Mechanical Design**





- TOMA (Tertiary Optic Mirror Assembly)
  - No changes
- o CGI Bench
  - No changes
- Structural Frame
  - No changes
- Radiator Panels
  - Re-sized based on recent thermal analysis



### **Summary**



- We have made significant progress advancing coronagraph technology for obscured pupil telescopes such as AFTA
  - Achieved performance in the lab ~1.6E-9 at 10% bandwidth
    - Static environment
    - High photon flux
- On-going work to address additional challenges, especially in low-flux (i.e., longer duration) environment
  - Drifts from the system, such as deformable mirrors
  - Detector flux-dependent characteristics at low flux levels as a result of radiation degradation (EMCCD)
  - Digging dark hole with V=3-5 mag star



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